MASTER OF FINANCIAL MATHEMATICS CURRICULUM

The **Master of Financial Mathematics (MFM)** program consists of four course sequences:

Fall	**Spring**
FM 5091	FM 5092
FM 5011	FM 5012
FM 5021	FM 5022
FM 5031	FM 5032

These sequences may be taken either in parallel or sequentially, following their numerical order (with the exception of FM 5091/5092, -that is recommended to be taken as early as possible.)

The MFM program is structured with a balance between theory and practice in mind. It features rigorous coursework in mathematics and statistics alongside a practicum course that is comprised of a variety of modules taught by industry professionals. In order to provide additional experience, students are invited to participate in modeling workshops in which they work in teams on a project mentored by a financial industry practitioners.

Student admitted in the program often have a variety of backgrounds. Some need to “brush up” on their mathematical foundation in order to be better prepared for the high level of mathematics throughout the MFM courses. The sequence **FM 5001/5002** is offered to these students. It is not a core sequence of the MFM program, however, students who do not have the appropriate mathematical background are required to complete it before taking any of the FM 5011/5012, FM 5021/5022 and FM 5031/5032. Together with FM 5091/5092, FM 5001/5002 form the **Fundamentals of Quantitative Finance (FQF)** Post Baccalaureate Certificate program.

The MFM program welcomes working individuals who are planning to change careers or enhance their understanding of quantitative finance. **The courses are offered in the evening and structured to accommodate full time working students.**

Courses

FM 5091/5092 Computation, Algorithms and Coding in Finance:

This sequence is intended to introduce students to the principles and practicalities of programming in the context of finance. Students will first be exposed to programming through MATLAB during the first semester. A large minority of the first semester and the whole of the second semester are then dedicated to learning C#. The class is project-based and students are evaluated on the quality and functionality of their code. All projects aim to solve practical finance problems dealing with financial derivatives, simulation, and optimization.

FM 5011/5012 Mathematical Background for Finance:

A theoretical sequence that focuses on graduate level mathematics and statistics that builds a solid foundation for modeling and using financial data.

FM 5011: This course covers the basics of probability and measure theory useful in stochastic calculus. Its purpose is to develop many of the advanced mathematical tools that are necessary for the understanding of stochastic calculus and the derivation of the Black Scholes option pricing formula. Topics will include: Sample spaces, Lebesgue measure and Lebesgue integral, limit theorems, martingales, elements of stochastic processes (example: Brownian motion), stochastic integration and Ito's lemma, stochastic differential equations, some numerical approximations (example: Euler and Milstein), the derivation of the Black-Scholes option pricing formula.

FM 5012: The objective of this course is to introduce core ideas behind statistical methods and optimization techniques, with a special focus on their application in financial mathematics. Topics include univariate and multivariate random variables, distributions, time series analysis - especially ARMA and GARCH models, univariate and multivariate regressions and optimization – theory and applications.

FM 5021/5022 Mathematical Theory Applied in Finance:

FM 5021: Linear contracts: forwards, futures and swaps. Arbitrage. Cash and carry arguments. Introduction to the valuation of options, binomial tree approach, delta-hedging argument in discrete time, and Monte Carlo simulation. Basic properties of the Brownian Motion, stochastic integral and Itō's lemma. Black-Scholes-Merton model. Delta-hedging argument in continuous time. Greek letters. Volatility smiles.

FM 5022: Review of Black-Scholes, Greeks and shortcomings. Value at risk. Principal component analysis. Introduction to time series, applications to volatility estimation: ARCH, GARCH. Exotic Options. Stochastic and local volatility models. Equivalent martingale measure approach. Interest rate derivatives, standard market models, 1-factor and 2-factor models of the short rate. Heath-Jarrow-Morton model. LIBOR market model.

FM 5031/5032 Practitioners Course

This practicum sequence features four modules that are taught by financial industry practitioners. Each module is an independent mini-course that exposes students to various aspects of financial practice.

Fixed Income Mathematics and Risk Management: In this module you will learn about fixed income markets and the variety of instruments traded. Using Risk Management as a motivator, we explore various interest rate derivatives and the underlying mathematics necessary to understand and manage them. You will learn how to construct yield curves, measure interest rate risk, and calibrate stochastic interest rate models. The final project will be an Asset Liability Management application and will involve Monte Carlo simulation.

Risk and Asset Allocation: The objective of this course is to provide a grounding in applied probability and statistics as it relates to the measurement of financial risk. The material is mainly organized around the text "Quantitative Risk Management, Concepts, Techniques, and Tools (Revised Edition)" by Alexander McNeil, Rüdiger Frey, and Paul Embrechts. Quizzes and assignments motivate the acquisition of vocabulary, financial and mathematical concepts, and scientific computing techniques. Projects provide exposure to the practice of professional research.

Copula Models and Markov chain Monte Carlo (MCMC): In this module we will review foundations of Bayesian statistical models and Monte Carlo methods leading to the construction of Metropolis-Hastings algorithm and Gibbs sampling. Copula models will be introduced and reassessed in the context of stochastic simulation. Case studies in credit risk analysis and economic capital evaluation will utilize the material learned in two prior modules in 5031. The mid-term simulation project will be presented by small groups in a classroom environment to a panel of industry representatives.

Volatility Data Analysis: Volatility Data Analysis: In this module, students will apply their knowledge of options theory and statistics to complete large data analysis projects. The analyses will focus on equity volatility, and will utilize the historical options data set provided by our partners at Delta Neutral. We will compare various volatility forecasting methodologies and also analyze the replication of variance swaps with vanilla options. Readings for the module will be sourced from industry white papers.

FM 5990 - Topics in Financial Mathematics: Financial Data Analysis and Visualization Using Python

The first part of the course is an introduction to financial data analysis and data visualization in Python. We use Jupyter notebooks and cover the numpy, pandas, and matplotlib packages. The second part of the course covers various supervised and unsupervised machine learning techniques including regression, k-nearest neighbors, principal components analysis, and k- means. This course is project-based and pass/fail. All exercises and projects use real-world financial data.

Projects and assignments will be turned in through Github, a framework for version control and collaboration.

Note: This course is optional and offered periodically.

FM 5001/5002 Preparation for Financial Mathematics:

This is a two-semester refresher sequence in the mathematical background needed for the Financial Mathematics Master Degree program at the University of Minnesota, especially for the sequence FM 5011/5012. The main topics for review are calculus (especially multivariable calculus), linear algebra, probability theory, and differential equations (including an introduction to partial differential equations, with most of the emphasis on linear algebra and probability theory. It is assumed that students have had at least a course in multivariable calculus. Throughout the course, connections are made to basic concepts in financial mathematics.

Additional Course Work

As an MFM student taking additional courses and/or getting a Minor are options, but are not required to receive your MFM. You do not need to decide at the beginning of your MFM if you will be taking additional courses or getting a minor. However you must make that decision and include it in your degree completion plan at least nine months before you graduate. The list below outlines the departments and subject areas where MFM students have been approved to take additional courses and/or talk with that department about pursuing a minor.

IMPORTANT: To receive a minor degree in any of the areas listed below, you need to get the approval of the department/program that offers the minor, to make sure that the courses you have chosen satisfy the specific minor's requirement.

- Management
- Statistics
- Applied Economics
- Economics
- Computer Science
- Additional Mathematics
- Industrial & Systems Engineering
- World Economy and Rates